I – Problem Statement Title (04-GS094)

Health Monitoring to Detect Failure of Prestressing (PS) Cables in Segmental Box-girder Bridges

II – Research Problem Statement

Question: How can we ensure that post-tensioned and segmentally constructed bridge perform adequately as designed, and how can we address possible affects of premature loss of prestress due to cable-breaks?

Health monitoring is an emerging science that may be used to detect failure of prestressing (PS) cables in segmental box-girder bridges and other post-tensioned bridges.

III – Objective

To develop the following:

a) Indices/responses/signatures that will provide insight into effects of failure in PS cables in special signature structures.
b) Specification guidelines for instrumentation (selection of sensor type, data acquisition etc) to facilitate monitoring such important structures.

IV - Background

Several signature structures incorporating newer materials Light weight concrete, high performance concrete) and methods of construction (segmental, cable stayed) are being built in California. These structures, depending on their type, incorporate a significant amount of PS or utilize cables as primary load-resisting components. It is conceivable that, during the design life of these structures, the PS cables or the load carrying cables may break due to several reasons (eg. corrosion). In segmental type construction, there is a need to develop a monitoring strategy that will help to identify issues such as cable breaks, loss in prestress, and other possible mechanisms that may cause a significant reduction in the bridge capacity.

Proposed Methodology

It is proposed that several (3 or 4) 2-celled box-girders or other girder types (preferably ½ to ¼ scale) be built – similar to the segmental bridges now being constructed) and instrumented. The specimens should be fabricated in a manner that will permit the researchers to deliberately induce cable failures sequentially. Through a combination of instrumentation that includes strain-measuring devices, “listening devices” and accelerometers, a procedure can be developed to identify the effects of deliberately induced deterioration.

V – Statement of Urgency and Benefits

A. Support of the Department's Mission/Goals:
(Improving Mobility: Safety and Reliability)

Nearly 90% of the bridges built in California are post-tensioned box-girders. In addition, California has been increasingly incorporating segmental bridge construction, particularly in toll bridges and other major bridges. On such major bridges, it is important to be able to identify any adverse effects of loss of prestress in a timely manner. This would help the maintenance engineers to take remedial steps without significantly impacting traffic or impacting public safety. Early detection of prestress loss will also help in designing remedial actions- this will lead to improved bridge life-cycle costs.

B. Return on Investment:

Costs associated with delays affecting the traveling public are estimated to be in the millions of dollars.

Early detection of loss of prestress in post-tensioned and segmentally constructed bridges will lead to better bridge maintenance, proper design of bridge rehabilitation and changes to bridge design and construction. All these steps will directly lead to reduced life-cycle costs and reduced delays and improved safety.

VI – Related Research

VII – Deployment Potential

The proposed research will:

1. Identify critical measurement parameters that will detect the effects of deterioration in P/S cables – such as due to cable snapping.
2. Develop guidelines for bridge instrumentation.
3. Develop "monitoring specifications" that will be incorporated into construction specifications.

These issues, when solved, will provide a means to develop preventive measures (thereby reducing the need for replacement / traffic disruptions) and extend structure's life.